

**CLAIMS**

1. Process for producing ion exchange membranes, which comprises the steps of:

a) Providing a matrix material, comprising a polymeric component chosen from the  
5 group consisting of monomeric and oligomeric polymer precursors and cross-linkable polymers;

b) Introducing in said matrix ion cation or anion exchange particles, or proton or hydroxyl or ion conducting particles or any combination of ion exchange, proton, hydroxide and ion conductivity, or cation or anion exchange polymers, or proton or  
10 hydroxyl or ion conducting polymers or any combination of ion exchange, proton, hydroxide and ion conductivity;

c) Mixing said particles or dissolving said polymer with said matrix;

d) Forming the resulting mixture into membrane configuration;

e) Ordering by an electric field said particles or ordering by an electric field the domains  
15 of said polymer formed by polymer-matrix phase separation upon solvent evaporation or cooling; and

f) if said matrix comprises or consists of a polymer precursor or a cross-linkable polymer, said precursor is cured concurrently with said ordering of said particles, or if the matrix comprises a polymer solution or polymer melt the said polymer solution is evaporated or  
20 the said polymer melt is maintained and then cooled concurrently with said ordering of said particles.

2. Process according to claim 1, wherein the matrix material comprises or consists of a polymer.

3. Process according to claim 1, wherein the matrix material comprises or consists of a  
25 polymer precursor.

4. Process according to claim 3, wherein the polymer precursor is cured concurrently with said ordering of the ion exchange particles.

5. Process according to claim 1, wherein the introduction in the matrix of the ion exchange particles and the mixing of said particles with said matrix are carried out  
30 concurrently.

6. Process according to claim 2, wherein the polymer is a material homogeneously mixed with ion exchange particles at elevated temperatures or when dissolved, and chemically resistant in acids and/or bases and /or oxidants.

7. Process according to claim 3, wherein the polymeric matrix is a material

5 homogeneously mixed with ion exchange particles or polymers when not yet cured at elevated temperatures or when dissolved, and when cured forms a polymer that is chemically resistant in acids and/or bases and or oxidants.

8. Process according to claim 1, wherein the polymeric matrix is chosen from the group consisting of polyethylene, polypropylene and polyamides.

10 9. Process according to claim 1, wherein the polymeric matrix is chosen from the group consisting of polyvinyl halogenated homo polymers, or copolymers, block-co- or tri-polymers or grafted polymers and engineering plastics.

10. Process according to claim 9, wherein the polyvinyl halogenated polymers are chosen from the group comprising polyvinylidene fluoride, polyvinylidene fluoride copolymers, 15 polyvinylidene chloride copolymers and polyvinyl chloride copolymers, polvinylidene fluoride (PVDF), polytetrafluoroethylene (PTFE), polyhexafluoropropylene (PHFP), polychlorotrifluoroethylene (PCTF), and co- and ter-polymers of the above, such as PVDF-co-PTFE, PVDF-co-PTFE, PVDF-co-PHFP, PVDF-co-PCTF, Poly(perfluoroalkyl dioxides) as a homopolymer and copolymers with other fluorinated 20 monomers such as vinylidene fluoride or tetrafluoroethylene.

11. Process according to claim 1, wherein the ion exchange particles are chosen from among porous and non-porous particles and have an ion exchange capacity of 2 to 5 meq/g (dry basis) for the cation exchanges and of 1 to 3 meq/g (dry basis) for the anion exchangers.

25 12. Process according to claim 1, wherein the ion exchange particles have diameters from 0.2 to 200 microns.

13. Process according to claim 12, wherein the ion exchange particles have diameters from 50 to 20  $\mu\text{m}$ .

14. Process according to claim 1, wherein the ion exchange particles are in the nano-size 30 range.

15. Process according to claim 1, wherein the ion exchange particles are spherically shaped beads.

16. Process according to claim 1, wherein the ion exchange particles are fibers, platelets or irregular shaped particles.

5 17. Process according to claim 1, wherein the ion exchange particles are in the form of a powder made of ground particles.

18. Process according to claim 1, wherein the ion exchange and/or proton or hydroxide or ion conducting particles or ion exchange and/or proton or hydroxide or ion conducting polymers are used in amounts from 10 to 70 wt% of the combined amount of the polymer matrix and of said particles.

19. Process according to claim 18, wherein the particles or polymers are used in amounts from 5 to 60 wt% of the combined amount of the polymer matrix and of said particles.

20. Process according to claim 18, wherein the particles or polymers are used in amounts from 20 to 40 wt% of the combined amount of the polymer matrix and of said particles.

15 21. Process according to claim 1, wherein the electric field has intensity from 50 to 20,000 V/cm.

22. Process according to claim 21, wherein the electric field has intensity from 800 to 1500 V/cm.

23. Process according to claim 1, wherein the electric field is an alternating field.

20 24. Process according to claim 23, wherein the electric field has a frequency from 5 to 2000 Hz.

25. Process according to claim 24, wherein the electric field has a frequency from 20 to 150 Hz.

26. Process according to claim 1, wherein the electric field is a DC field.

25 27. Process according to claim 1, wherein the electric field is applied for periods up to 10 hours.

28. Ion exchange or ion conducting membranes, according to claim 1, comprising a polymer matrix and ion cation or anion exchange particles; or proton or hydroxyl or ion conducting particles or any combination of ion exchange, proton, hydroxide and ion conductivity;; or domains of cation or anion exchange polymers, or proton or hydroxyl or

ion conducting polymers or any combination of ion exchange, proton, hydroxide and ion conductivity,, wherein said domains occurred by matrix polymer incompatibility, and , wherein said particles or domains are generally ordered.

29. Ion exchange or ion conducting membranes according to claim 26, wherein the  
5 matrix comprises a material chosen from the group consisting of polyethylene, polypropylene, polyamides, polybenzimidazole, polysulfones, polyether sulfones, polyvinylidene fluoride, polyvinylidene fluoride copolymers, polyvinylidene chloride copolymers and polyvinyl copolymers, the ion exchange or conducting particles or domains have an ion exchange capacity of 0.5 to 5meq/gr (dry basis) for the cation  
10 exchanges and of 1 to 3 meq/g (dry basis) for the anion exchangers, the diameters or the shortest dimension of which, are ranging from 0.002 to 200 microns, are in amounts from 10 to 70 wt% of the membrane.

30. Ion exchange or ion conducting membranes according to claim 26, having a configuration chosen from the group consisting of flat, tubular, capillary, or hollow fiber  
15 configurations.

31. Ion exchange or ion conducting membranes according to claim 28, having an improved passage of protons and a greater selective passage of protons compared to methanol or hydrogen gas compared to membranes wherein the particles or domains are not ordered.

20 32. Use of ion exchange membranes, comprising a polymeric matrix and ion exchange particles, wherein said particles are generally ordered in power sources.

33. Use of ion exchange or proton or hydroxyl or ion conducting membranes, comprising a polymeric matrix and ion exchange or conducting particles or ion exchange or proton or hydroxyl or ion conducting domains or any combination of ion exchange, proton,  
25 hydroxide and ion conductivity, wherein said membranes are used in power sources.

34. Use of ion exchange or ion conducting membranes according to claim 32, wherein the power sources are fuel cells.

35. Ion exchange membranes, comprising a polymeric matrix and ion exchange or conducting particles or domains or any combination of ion exchange, proton, hydroxide  
30 and ion conductivity,, wherein said particles or domains are generally ordered, for use in

power sources.

36. Ion exchange membranes, comprising a polymeric matrix and ion exchange particles or domains, wherein said particles or domains are generally ordered, for use in fuel cells.

37. Process according to claim 1, wherein the polymeric matrix is chosen from the
- 5 following group of polymers, made by condensation polymerization: polysulfone, polyphthalimidazole, polyether sulfone, polyphenylene sulfone, polyetherketone, polyether ketone, polyether ketone ether ketone, and other variations of polyether ketones and polysulfones, polyphenylene sulfide, phenylene sulfone and variations of sulfide and sulfone in the same polymer, polyethers based on polyphenylene oxide such as 2,6
- 10 dimethylphenylene, aromatic polyether imides, polyether amide-amide, aromatic polyamides and aromatic aliphatic polyamide combinations, polybenzimidazole, halomethylated derivatives of the above polymers on the aromatic or aliphatic groups.